BIOENG-313

From light to life: optics and imaging in biology

Schueder Florian

Cursus	Sem.	Type
Life Sciences Engineering	BA6	Obl.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Courses	2 weekly
Exercises	2 weekly
Number of positions	

Summary

This course introduces the principles of optics underlying modern biological imaging. Students learn how light interacts with matter, how optical systems form images, and how advanced fluorescence and super-resolution microscopy enable discoveries in biology and molecular medicine.

Content

This course connects fundamental concepts of electromagnetism and optics to modern imaging technologies that are transforming the life sciences. Students will learn how the physical nature of light determines our ability to observe, measure, and understand biological systems.
We begin by introducing light as an electromagnetic wave and discuss how Maxwell's equations lead to the wave description of light. Building on this foundation, we explore key optical properties including wavelength, frequency, polarization, absorption, and coherence. We also examine the behavior of light at interfaces, including refraction, total internal reflection, evanescent fields, and optical waveguiding in fibers.
Next, the course introduces geometric optics and image formation through lenses, mirrors, and other optical elements. These principles are then applied to biologically relevant optical instruments such as the human eye, cameras, telescopes, and microscopes. Concepts such as magnification, numerical aperture, contrast, and spatial resolution are developed to understand how optical systems generate images.
In the next part of the course, we focus on biological imaging and microscopy. We cover fluorescence microscopy and modern imaging modalities including widefield, confocal, TIRF, and light-sheet microscopy. Finally, we explore advanced methods that overcome classical resolution limits, including structured illumination microscopy (SIM), STED microscopy, single-molecule localization microscopy (PALM, STORM, DNA-PAINT), and expansion microscopy.
Throughout the course, emphasis is placed on how advances in optics and imaging enable discoveries in biology, biotechnology, and molecular medicine. Students will gain both a conceptual understanding of optical physics and an appreciation of how light-based technologies drive innovation in modern biology.

Keywords

Optics, Imaging, Microscopy

Assessment methods

The assessment will consist of a written examination based on the material covered in the lectures and the exercises completed throughout the semester.

Resources

Moodle Link

- https://go.epfl.ch/BIOENG-313